

EV AMERICA: HYBRID ELECTRIC VEHICLE (HEV) TECHNICAL SPECIFICATIONS

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**Prepared by
Electric Transportation Applications**

2001 HEV AMERICA FINAL TECHNICAL SPECIFICATIONS

MINIMUM VEHICLE REQUIREMENTS

The HEV America Program is sponsored by the U.S. Department of Energy Office of Transportation Technology to provide for independent assessment of Hybrid Electric Vehicles (HEVs). Vehicles tested under this program are evaluated against specific qualitative and quantitative metrics. The results provide potential users a method for comparing various HEVs against consistent standards and against each other, comparisons that might not otherwise be possible. The U.S. Department of Energy recognizes the HEV America program as requisite for funding of programs involving HEVs.

For a vehicle to be considered qualified for testing under the HEV America Program, it must meet the minimum criteria defined by “shall” terminology utilized in the Specification. [For clarity, the use of the word “Shall” defines minimum requirements, whereas the use of the word “Should” defines design and performance objectives.] Vehicles that do not or cannot meet all of the “Shall” requirements will be considered Prototypes, and will not be considered as having successfully completed the Program. The following requirements have been extracted from the body of the Vehicle Specification for convenience and clarity. In these requirements and in the Vehicle Specification, the term “Supplier” refers to the vehicle manufacturer. All of the following requirements must be met by any vehicle before it can receive consideration under the HEV America Program.

Vehicles to be tested to these Specifications shall be HEV which are defined as road vehicles that can draw propulsion energy from both of the following sources of stored energy 1) a consumable fuel and 2) a rechargeable energy storage system (RESS) that is recharged by an electric motor-generator system, an off vehicle electric energy source, or both.

- (1) Vehicles shall have a minimum payload of at least 400 pounds.
- (2) Suppliers shall provide the OEMs Gross Vehicle Weight Rating (GVWR). For Conversion vehicles, OEM GVWR shall not be increased.
- (3) Suppliers shall provide axle weights for the vehicle as delivered, and at full rated payload. For Conversion vehicles, OEM Gross Vehicle Axle Weight Ratings (GAWR) shall not be increased.
- (4) Seating capacity shall be a minimum of one driver and one passenger. Suppliers shall provide seating capacity (available seat belt positions) for their vehicle.
- (5) For conversion vehicles, if the Supplier changes the vehicle’s seating capacity from that specified by the OEM on their FMVSS placard, the seat(s) being added or abandoned shall be modified as required by 49 CFR 571.207, et al, and a new FMVSS placard installed as required by 49 CFR 567, 568 or 571, as applicable.
- (6) Suppliers shall provide recycling plans for batteries and other vehicle hazardous materials including how the plan has been implemented.

2001 HEV AMERICA FINAL TECHNICAL SPECIFICATIONS

- (7) Vehicles shall comply with the requirements of 49 CFR 571.105.S5.2.1, or alternatively, 49 CFR 571.105.S5.2.2 for parking mechanisms.
- (8) Vehicles shall comply with Federal Motor Vehicle Safety Standards applicable on the date of manufacture and such compliance shall be certified by the manufacturer in accordance with 49 CFR 567. Suppliers shall provide a completed copy of Appendix B with their submittal, indicating the method of compliance with each section of 49 CFR 571. If certification includes exemption, the exemption number issued by the National Highway Transportation Safety Administration (NHTSA), the date of its publication in the Federal Register and the page number(s) of the Federal Register acknowledging issuance of the exemption shall be provided along with Appendix B. Only exemptions for non-applicable requirements shall be allowed.
- (9) For vehicles with RESS system voltages of 48 volts and higher, batteries or capacitors and their enclosures shall be designed and constructed in a manner that complies with 49 CFR 571.305. For vehicles with RESS system voltages below 48VDC, batteries or capacitors, and their enclosures, shall be designed and constructed in accordance with the requirements of SAE J1766. Further, irrespective of RESS system voltage, batteries or capacitors, and electrolyte will not intrude into the passenger compartment during or following FMVSS frontal barrier, rear barrier and side impact collisions, and rollover requirements of 49 CFR 571.301. Suppliers shall provide verification of conformance to this requirement.
- (10) For conversion vehicles, the OEM passenger space shall not be intruded upon by the Rechargeable Energy Storage System (RESS) or other conversion materials.
- (11) Flywheels and their enclosures shall be designed and constructed such that there is complete containment of the flywheel energy storage system during all modes of operation. Additionally, flywheels and their enclosures shall be designed and constructed such that there is complete containment of the flywheel energy storage system during or following frontal barrier, rear barrier and side impact collisions, and roll-over requirements of 49 CFR 571.301. Suppliers shall provide verification of conformance to this requirement.
- (12) Batteries shall comply with the requirements of SAE J1718, and at a minimum shall meet the requirements of NEC 625-29(c) or (d) for charging in enclosed spaces without a vent fan.
- (13) Concentrations of explosive gases in the battery enclosure shall not be allowed to exceed 25% of the LEL (Lower Explosive Limit). Suppliers shall describe how battery boxes will be vented, to ensure any battery gases escape safely to atmosphere during and following normal or abnormal charging and operation of the vehicle. Battery gases shall not be allowed to enter the occupant compartment.

2001 HEV AMERICA FINAL TECHNICAL SPECIFICATIONS

- (14) If the vehicle is capable of off-board recharging of the RESS, the charger shall be capable of recharging the RESS to a state of full charge from any possible state of discharge in less than 12 hours, at temperatures noted in Section 5.5, as applicable.
- (15) If the vehicle is capable of off-board recharging of the RESS, the chargers shall use 120V or 208/240V single-phase 60-Hertz alternating current service, with an input voltage tolerance of $\pm 10\%$ of rated voltage.
- (16) Input current for chargers operating at 208V and 240V shall be compatible with 40-ampere circuit breakers
- (17) If the vehicle is capable of off-board recharging of the RESS using a 208/240V charger, chargers shall have a true power factor of .95 or greater and a harmonic distortion rated at $\leq 20\%$ (current at rated load).
- (18) The RESS charger shall be fully automatic, determining when “end of charge” conditions are met and transitioning into a mode that maintains the RESS at a full state of charge while not overcharging it, if continuously left on charge.
- (19) The controller/inverter shall limit the minimum RESS battery discharge voltage to prevent degradation of battery life.
- (20) Personnel protection systems shall be in accordance with the requirements of UL Standard 2202 and shall be determined based upon RESS system voltages. All personnel protection systems shall meet the requirements specified in the applicable sections of UL2231-1 and 2231-2.
- (21) Any off-board conductive or inductive type charging systems shall comply with the Personnel Protection requirements of UL-2202.
- (22) Vehicles shall not contain exposed conductors, terminals, contact blocks or devices of any type that create the potential for personnel to be exposed to 60 volts or greater (the distinction between low-voltage and high voltage, as specified in SAE J1127, J1128, et al.). Access to any high voltage components shall require the removal of at least one bolt, screw, or latch. Devices considered to be high voltage components shall be clearly marked as HIGH VOLTAGE. Additionally, cable and wire marking shall consist of orange wire and/or orange sleeving as identified in SAE-J1127.
- (23) Vehicles shall be accompanied by non-proprietary manuals for parts, service, operation and maintenance, interconnection wiring diagrams and schematics.
- (24) For propulsion power systems with voltages greater than or equal to 48VDC, the system shall be isolated from the vehicle chassis such that leakage current does not exceed 0.5 MIU.

2001 HEV AMERICA FINAL TECHNICAL SPECIFICATIONS

- (25) Charging circuits for RESS battery systems with voltages greater than or equal to 48VDC shall be isolated from the vehicle chassis such that ground current from the grounded chassis does not exceed 5 mA at any time the vehicle is connected to an off-board power supply.
- (26) Replacement tires shall be commercially available to the end user in sufficient quantities to support the purchaser's needs.
- (27) Tires provided as original equipment by the HEV Supplier shall not have warranty restrictions in excess of those of the tire's manufacturer's, unless the HEV Supplier is the sole warrantor for the tires.
- (28) The vehicle shall be prevented from being driven with the key turned on and the drive selector in the DRIVE or REVERSE position while the vehicle's charge cord is attached. Additionally, the following interlocks shall be present:
 - The controller shall not initially energize to move the vehicle with the gear selector in any position other than "PARK" or "NEUTRAL;"
 - The start key shall be removable only when the "ignition switch" is in the "Off" position, with the drive selector in "PARK;"
 - With a pre-existing accelerator input, the controller shall not energize or excite such that the vehicle can move under its own power from this condition.
- (29) All vehicles shall comply with the FCC requirements for unintentional emitted electromagnetic radiation, as identified in 47 CFR 15, Subpart B, "Unintentional Radiators."
- (30) For vehicles equipped with a disconnect for the main propulsion batteries, this disconnect shall be capable of interrupting maximum rated controller/inverter current. The Supplier shall describe the automatic disconnect provided for the main propulsion batteries. [See Section 7.3.]
- (31) Suppliers shall supply Material Safety Data Sheets (MSDS) for all unique hazardous materials the vehicle is equipped with, including RESS batteries or capacitors, and auxiliary batteries.
- (32) If a Supplier provides a vehicle with parallel battery packs, the Supplier shall provide detailed information on the equipment and charging algorithms required to prevent the parallel strings from becoming unbalanced.
- (33) Vehicles to be tested to these Specifications shall be HEV which are defined as road vehicles that can draw propulsion energy from both of the following sources of stored energy 1) a consumable fuel and 2) a rechargeable energy storage system (RESS) that is recharged by an electric motor-generator system, an off vehicle electric energy source, or both.
- (34) RESS's shall be battery, capacitor, or electromechanical flywheel technology-based as defined in SAE J1711.
- (35) For vehicles using fuels other than gasoline, Suppliers shall indicate compliance with appropriate and applicable standards from SAE, NFPA, etc.

2001 HEV AMERICA FINAL TECHNICAL SPECIFICATIONS

- (36) Vehicles shall not auto-start the engine to charge the batteries while the vehicle is parked and the key switch is in the OFF position.

The following sections constitute the Technical Requirements of the Specification. Information has been categorized according to component and/or function. These sections provide an overview of the requirements and recommendations for Suppliers to use. This Technical Specification establishes the minimum requirements for Production Level Hybrid Electric vehicles, as well as identifying design and performance objectives. Suppliers shall clearly describe the vehicle they are proposing by completing a copy of Appendix A. Drawings showing the installation, location and layout of the components including the RESS, electric motor-generator(s), transmission(s), and controller(s), off-board charging ports, engine, and fuel system should be provided. The driveline should also be described, i.e., driven wheels, transmission type, gear ratios, etc. Suppliers should include any other information required to describe the vehicle including fuel requirements, charging methods, each possible mode of operation and recommended modes of operation.

No inference should be drawn by Suppliers or any other person that the measures listed in this specification are sufficient to make the vehicle safe, and each Supplier shall acknowledge **in writing** that 1) it is solely responsible for determining whether each vehicle offered for sale is safe, and 2) it is not relying on HEV America, Electric Transportation Applications, or the U.S. Government as having, by this specification and its requirements, established minimally sufficient safety standards. This written statement shall be provided in the Supplier's proposal.

2001 HEV AMERICA FINAL TECHNICAL SPECIFICATIONS

1.0 REGULATORY REQUIREMENTS

1.1 FMVSS CERTIFICATION

Vehicles shall comply with Federal Motor Vehicle Safety Standards applicable on the date of manufacture and such compliance shall be certified by the manufacturer in accordance with 49 CFR 567. Suppliers shall provide a completed copy of Appendix B indicating the method of compliance with each required section of 49 CFR 571. If certification includes exemption, the exemption number issued by the National Highway Transportation Safety Administration (NHTSA), the date of its publication in the Federal Register and the page number(s) of the Federal Register acknowledging issuance of the exemption shall be provided along with Appendix B. Exemptions for any reason other than non-applicability shall not be allowed.

1.2 VEHICLE EMISSIONS CERTIFICATION

Vehicles should be certifiable under current California Air Resources Board (CARB) or Environmental Protection Agency (EPA) regulations. If the vehicle is equipped with a fuel-fired heater, the heater should be certified to the same level as the base vehicle.

1.3 SAFETY FEATURES

Suppliers should describe safety measures and safety-related design features included in their vehicle design and provide an explanation of the purpose and anticipated effect on vehicle reliability and performance of any such safety measure or design feature.

1.4 MATERIAL SAFETY DATA SHEETS

Suppliers shall supply Material Safety Data Sheets (MSDS) for all unique hazardous materials the vehicle is equipped with, including RESS batteries or capacitors, and auxiliary batteries.

1.5 BATTERY AND HAZARDOUS MATERIALS RECYCLING PLANS

Suppliers shall provide recycling plans for batteries and other vehicle hazardous materials including how the plan has been implemented. This plan should also identify post-purchase costs associated with recycling that will be passed on to the vehicle purchaser.

1.6 FEDERAL COMMUNICATIONS REQUIREMENTS

All vehicles shall comply with the FCC requirements for unintentional emitted electromagnetic radiation, as identified in 47 CFR 15, Subpart B, "Unintentional Radiators."

**2001 HEV AMERICA FINAL
TECHNICAL SPECIFICATIONS**

1.7 ELECTROMAGNETIC FIELD MINIMIZATION

Vehicles should be designed to minimize occupant exposure to electromagnetic fields generated by the propulsion system.

2001 HEV AMERICA FINAL TECHNICAL SPECIFICATIONS

2.0 CHASSIS

2.1 RATED PAYLOAD

Vehicles shall have a minimum payload of at least 400 pounds.

2.2 CURB WEIGHT AND GROSS VEHICLE WEIGHT RATING (GVWR)

For conversions, OEM GVWR shall not be increased. Suppliers should provide the curb weight and rated payloads of their vehicles. For conversion vehicles, Suppliers shall specify the OEMs gross vehicle weight rating (GVWR).

2.3 VEHICLE WEIGHT DISTRIBUTION

For conversions, OEM Gross Vehicle Axle Weight Ratings (GAWR) shall not be increased. Suppliers shall provide axle weights for the vehicle as delivered, and at full rated payload.

2.4 SPEEDOMETER AND ODOMETER

Speedometers and odometers should have an accuracy of at least $\pm 5\%$.

2.5 BRAKING AND STEERING PERFORMANCE

Braking and steering efforts should be similar to OEM models of comparable size and weight .

2.6 TIRES

Tires shall be subject to the following requirements:

- Tires provided with the vehicle shall be the standard tire offered by the HEV Supplier for the vehicle being proposed.
- Tires shall correspond to the requirements of the placard installed in accordance with 49 CFR 571.109, 110, 119 and 120, as applicable.
- Suppliers shall specify manufacturer, model and size of the standard tire.
- Tires sizes and inflation pressures shall be in accordance with the requirements of the placard.
- At no time shall the tire's inflation pressure exceed the maximum pressure imprinted upon that tire's sidewall.
- The tire shall be operable across the entire operation/load range of that vehicle.
- Replacement tires shall be commercially available to the end user in sufficient quantities to support the purchaser's needs.
- Tires provided as original equipment by the HEV manufacturer shall not have warranty restrictions in excess of those of the tire's manufacturer, unless the HEV Supplier is the sole warrantor for the tires.

2001 HEV AMERICA FINAL TECHNICAL SPECIFICATIONS

2.6 TIRES (continued)

- If the vehicle may be equipped with more than one standard tire, this information shall be provided for each type/manufacturer of each standard tire.

2.7 GROUND CLEARANCE

Vehicles should have a ground clearance of at least five (5) inches to all sprung portions of the vehicle, with the vehicle loaded with rated payload (e.g. to GVWR).

3.0 VEHICLE CHARACTERISTICS

3.1 SEATING CAPACITY

Seating capacity shall be a minimum of 1 driver and 1 passenger. Suppliers shall specify seating capacity (available seat belt positions) for their vehicle. For conversion vehicles, if the vehicle's seating capacity is changed from that specified by the OEM on their FMVSS placard, the seat(s) being added or abandoned shall be modified as required by 49 CFR 571.207, et al, and a new FMVSS placard installed as required by 49 CFR 567, 568 or 571, as applicable.

3.2 PASSENGER AND CARGO SPACE

For conversion vehicles, the OEM passenger space shall not be intruded upon by the Rechargeable Energy Storage System (RESS) or other conversion materials. Suppliers should specify interior passenger and cargo dimensions and volumes.

3.3 ELECTROMAGNETIC SUSCEPTIBILITY

Vehicles should comply with the relevant sections of SAE J551 for electromagnetic radiated fields. Vehicles should not be susceptible to externally generated electromagnetic radiation from an on-board transmitter (i.e., interaction will not preclude operation of any system(s) required for proper operation of the vehicle).

2001 HEV AMERICA FINAL TECHNICAL SPECIFICATIONS

4.0 DRIVE SYSTEM

4.1 TRANSMISSION

The vehicle may utilize a single speed, multi-speed automatic, manual transmission, or a Continuously Variable Transmission (CVT), and shall have a parking mechanism.

4.2 REGENERATIVE BRAKING SYSTEM

Regenerative braking should not adversely impact the vehicle's braking ability on varying road surfaces. Suppliers should describe the operation of the regenerative braking system and its interface with braking and anti-lock brake systems.

4.3 OVERHEATING

The vehicle drive-train system should be capable of continuous operation at maximum vehicle speed and/or sustained grades without overheating or loss of component life over the range of ambient temperatures specified in Section 5.5.

4.4 BATTERY VOLTAGE LIMITS

The controller/inverter shall limit the minimum RESS battery discharge voltage to prevent degradation of battery life, and should limit the maximum regeneration voltage to prevent external gassing of the batteries. Suppliers should specify the voltage limits and describe how these limits are implemented.

4.5 DRIVE TRAIN

Drive train components should not produce or develop unusual vibrations over the entire design speed range of the vehicle.

4.6 PARKING MECHANISM

Vehicles shall comply with the requirements of 49 CFR 571.105.S5.2.1, or alternatively, 49 CFR 571.105.S5.2.2 for parking mechanisms.

2001 HEV AMERICA FINAL TECHNICAL SPECIFICATIONS

5.0 VEHICLE PERFORMANCE

Vehicle performance is divided into separate categories depending upon vehicle overall design and available operating modes. Vehicles which are capable of driver selectable modes will have performance goals for each of those modes. The performance goals apply only if the vehicle is capable of the mode stated. [e.g., vehicles that cannot be operated in RESS only mode will not be tested in that mode.]

5.1 ACCELERATION

The vehicle should have a 0-50 mph acceleration time of 13.5 seconds or less with the vehicle loaded to it's design curb-weight plus 332 pounds in each of the selectable modes of operation, as applicable.

- 5.1.1 Consumable Fuel Energy Converter (CFEC) mode only.
- 5.1.2 Rechargeable Energy Storage System (RESS) mode only, starting at 100% SOC.
- 5.1.3 Rechargeable Energy Storage System (RESS) mode only, starting at 50% SOC.
- 5.1.4 All other possible Hybrid Electric Vehicle (HEV) modes that are specified as user-selectable in the vehicle's operating manual, and starting with the RESS at 100% SOC.
- 5.1.5 All other possible Hybrid Electric Vehicle (HEV) modes that are specified as user-selectable in the vehicle's operating manual, and starting with the RESS at 50% SOC.

5.2 MINIMUM TOP SPEED

The vehicle should have a minimum top speed of 70 MPH with the vehicle loaded to it's design curb-weight plus 332 pounds in each of the selectable modes of operation, as applicable.

- 5.2.1 Consumable Fuel Energy Converter (CFEC) mode only.
- 5.2.2 Rechargeable Energy Storage System (RESS) mode only, starting at 100% SOC.
- 5.2.3 Rechargeable Energy Storage System (RESS) mode only, starting at 50% SOC.
- 5.2.4 All other possible Hybrid Electric Vehicle (HEV) modes that are specified as user-selectable in the vehicle's operating manual, and starting with the RESS at 100% SOC.
- 5.2.5 All other possible Hybrid Electric Vehicle (HEV) modes that are specified as user-selectable in the vehicle's operating manual, and starting with the RESS at 50% SOC.

2001 HEV AMERICA FINAL TECHNICAL SPECIFICATIONS

5.3 HIGH SPEED GRADEABILITY¹

Vehicles should achieve a minimum sustainable speed of 55 mph on a 3% grade, and 45 mph on a 6% grade, with the vehicle loaded to its design curb-weight plus 332 pounds, in each of the selectable modes of operation, as applicable.

- 5.3.1 Consumable Fuel Energy Converter (CFEC) mode only.
- 5.3.2 Rechargeable Energy Storage System (RESS) mode only, starting at 100% SOC.
- 5.3.3 Rechargeable Energy Storage System (RESS) mode only, starting at 50% SOC.
- 5.3.4 All other possible Hybrid Electric Vehicle (HEV) modes that are specified as user-selectable in the vehicle's operating manual, and starting with the RESS at 100% SOC.
- 5.3.5 All other possible Hybrid Electric Vehicle (HEV) modes that are specified as user-selectable in the vehicle's operating manual, and starting with the RESS at 50% SOC.

5.4 LOW SPEED GRADEABILITY

Vehicles should be capable of starting and ascending a 25% with the vehicle loaded to its design curb-weight plus 332 pounds in each of the selectable modes of operation, as applicable.

- 5.4.1 Consumable Fuel Energy Converter (CFEC) mode only.
- 5.4.2 Rechargeable Energy Storage System (RESS) mode only, starting at 100% SOC.
- 5.4.3 Rechargeable Energy Storage System (RESS) mode only, starting at 50% SOC.
- 5.4.4 All other possible Hybrid Electric Vehicle (HEV) modes that are specified as user-selectable in the vehicle's operating manual, and starting with the RESS at 100% SOC.
- 5.4.5 All other possible Hybrid Electric Vehicle (HEV) modes that are specified as user-selectable in the vehicle's operating manual, and starting with the RESS at 50% SOC.

¹ EV America performs a 3% Grade at 55mph Test (ETA-TP004), but does not perform a 6% Grade at 45mph Test. This is per agreement with California's Air Resource Board (CARB), South Coast Air Quality Management District (SCAQMD) and the California Energy Commission (CEC).

2001 HEV AMERICA FINAL TECHNICAL SPECIFICATIONS

5.5 TEMPERATURE DURABILITY

Vehicles should be capable of standing for extended periods in extreme temperatures without damage to or failure of the vehicle or its systems. This includes ambient air temperatures of -20°F to +120°F, paved surface temperatures of 150°F, and occupant compartment temperatures of 170°F.

5.6 WATER DURABILITY

Vehicles should be able to drive through two (2) inches of standing water at a speed of 20 mph without damage, without becoming inoperable, and without battery to chassis leakage current exceeding 0.5 MIU per UL Standard 2202.

Vehicles should be capable of setting in eight (8) inches of standing water for 15 minutes without damage, becoming inoperable, and without battery to chassis leakage current exceeding 0.5 MIU per UL Standard 2202.

5.7 ENERGY EFFICIENCY DRIVE CYCLES

Vehicles should be able to complete two (2) Urban Dynamometer Driving Schedules (UDDS) followed by two (2) Highway Fuel Economy Driving Schedules to obtain the fuel/energy efficiency. This test will be conducted with the vehicle loaded to its design curb-weight plus 332 pounds in each of the selectable modes of operation, as applicable.

5.7.1 Consumable Fuel Energy Converter (CFEC) mode only.

5.7.2 Rechargeable Energy Storage System (RESS) mode only, starting at 100% SOC.

5.7.3 All possible Hybrid Electric Vehicle (HEV) modes that are specified as user-selectable in the vehicle's operating manual, and starting with the RESS at 100% SOC.

5.8 FUEL ECONOMY

Vehicles should be accompanied with fuel economy data from Manufacturer's testing. Vehicles will be tested for fuel economy while driving through a combined drive cycle test consisting of two (2) Urban Dynamometer Driving Schedules (UDDS) followed by two (2) Highway Fuel Economy Driving Schedules in each of the selectable modes of operation, as applicable, with the RESS battery system at its manufacturer's-specified normal state of charge.

6.0 RECHARGEABLE ENERGY STORAGE SYSTEM (RESS)

6.1 BATTERY TYPE

Suppliers should provide a detailed description of the RESS battery pack (including specific energy, specific power and discharge capacity to 80% DOD at the one-hour rate), battery pack voltage, number of battery modules, and a summary of previous performance tests. If different, customer available and battery available DOD ratings shall both be provided.

6.2 BATTERY CHARACTERISTICS

Batteries shall comply with the requirements of SAE J1718. For valve regulated batteries, the internal pressure level at which batteries vent should be specified. Suppliers should describe projected life (in cycles) at a specified level of discharge, how battery life is maximized, how end of life of each battery module and of the full battery pack is determined and how battery temperature gradients are minimized. Suppliers should specify maximum normal and abnormal gassing rates for the battery pack.

Vehicles shall not auto-start the engine to charge the batteries while the vehicle is parked and the key switch is in the OFF position.

For vehicles capable of off-vehicle charging (OVC), RESS batteries shall meet the requirements of NEC 625-29(c) or (d) for charging in enclosed spaces without a vent fan.6.6. The vehicle shall be labeled as not requiring ventilation for charging (or have the appropriate classification label from a UL-recognized Testing Laboratory).

6.3 MAXIMUM STATE OF DISCHARGE

Suppliers should indicate the level of charge below which the batteries should not be discharged. This should include the specific parameters the Battery Management System utilizes to prevent over-discharge. At a minimum the Ah rating(s), module voltage(s), and battery pack voltage(s) should be provided. Further, this should be consistent with information provided in the Owner's Manuals.

6.4 BATTERY PACK

Suppliers should specify the weight of each battery module, and the weight of the battery pack (including removable pack structures). Suppliers should describe how batteries are installed in the vehicle (including details of module connection), the method of installation and removal of the batteries (and the battery box, if required) for maintenance and repair, the time required for battery removal and any special training, tools or equipment required for battery removal.

2001 HEV AMERICA FINAL TECHNICAL SPECIFICATIONS

6.5 ELECTROLYTE CONTAINMENT

For vehicles with RESS system voltages of 48 volts and higher, batteries or capacitors and their enclosures shall be designed and constructed in a manner that complies with 49 CFR 571.305. For vehicles with RESS system voltages below 48VDC, batteries or capacitors, and their enclosures, shall be designed and constructed in accordance with the requirements of SAE J1766. Further, irrespective of RESS system voltage, batteries or capacitors, and electrolyte will not intrude into the passenger compartment during or following FMVSS frontal barrier, rear barrier and side impact collisions, and rollover requirements of 49 CFR 571.301. Suppliers shall provide verification of conformance to this requirement.

6.6 BATTERY BOX

Concentrations of explosive gases in the battery box shall not be allowed to exceed 25% of the LEL (Lower Explosive Limit). Suppliers shall describe how battery boxes will be vented, to allow any battery gases to escape safely to atmosphere during and following normal or abnormal charging and operation of the vehicle. Battery gases shall not be allowed to enter the occupant compartment.

Batteries shall comply with the requirements of SAE J1718. and at a minimum shall meet the requirements of NEC 625-29(c) or (d) for charging in enclosed spaces without a vent fan.6.6.

Suppliers should describe the methods used to prevent or accommodate condensation in the battery box, and the quantity and maximum rate of explosive gas generation, by gas type, under normal and abnormal charging conditions.

6.7 PARALLEL BATTERY PACKS

Suppliers should not provide vehicles with parallel battery packs. If a Supplier provides a vehicle with parallel battery packs, the Supplier shall provide detailed information on the equipment and charging algorithms required to prevent the parallel strings from becoming unbalanced.

6.8 BATTERY MAINTENANCE

Maintenance requirements for the RESS batteries should be described and any associated cost(s) to the consumer/end user clearly defined.

6.9 FLYWHEELS

Flywheels and their enclosures shall be designed and constructed such that there is complete containment of the flywheel energy storage system during all modes of operation. Additionally, flywheels and their enclosures shall be designed and constructed such that there is complete containment of the flywheel energy storage system during or following frontal barrier, rear barrier and side impact collisions, and

2001 HEV AMERICA FINAL TECHNICAL SPECIFICATIONS

6.9 FLYWHEELS (continued)

rollover requirements of 49 CFR 571.301. Suppliers shall provide verification of conformance to this requirement.

6.10 ADDITIONAL RESS COMPONENT MAINTENANCE

Maintenance requirements for other RESS components (e.g., flywheels, ultra capacitors) should be described and any associated cost(s) to the consumer/end user should be clearly defined.

6.11 BATTERY CHARGING ALGORITHM

Vehicle suppliers should verify that the method(s) of charging the RESS batteries and the charging algorithm(s) do not impact the battery warranty available to end-user. This should be independent of the charging methods for the RESS (OVC or non-OVC). The charging algorithm(s) should have been reviewed and approved by the battery manufacturer.

6.12 BATTERY MANAGEMENT SYSTEM

The vehicle should be equipped with a Battery Management System (BMS). This system should control propulsion battery pack and module voltages, temperatures and state of charge. Further, the BMS should automatically limit battery discharge below a pre-determined minimum level. If a BMS is provided, suppliers should provide a description of the BMS' operation. This description should be consistent with that provided in the owner's manual.

The onboard charging system, if so equipped, should include equipment to maintain each module in the battery pack at equal temperature and within the allowed temperature range of the battery throughout each charge-discharge cycle.²

If the vehicle is not equipped with a BMS, manufacturers should provide information on how charging of the RESS batteries/energy storage components is accomplished.

6.13 FUEL SYSTEMS

For vehicles using fuels other than gasoline, manufacturers shall indicate compliance with appropriate and applicable standards from SAE, NFPA, etc. [e.g., for vehicles using Compressed Natural Gas as fuel, manufacturers should indicate compliance with NFPA 52, "Compressed Natural Gas (CNG) Vehicular Fuel Systems Code," as well as 49 CFR 571.303 and 304.] For pressurized fuel systems, OEMs/converters should provide expected refueling times at various system fuel pressures and tank fills.

² Other certifying or qualifying agencies, such as California's South Coast Air Quality Management District (SCAQMD) and the California Energy Commission (CEC), may have requirements for maintaining battery temperatures that differ from EV America. Should bidders wish to be considered under those qualification and/or incentive programs using EV America data, those entities should be consulted.

2001 HEV AMERICA FINAL TECHNICAL SPECIFICATIONS

6.14 RESS ENERGY SOURCE

Rechargeable Energy Storage Systems (RESS) shall be battery, capacitor, or electromechanical flywheel technology-based as defined in SAE J1711.

7.0 ELECTRICAL

7.1 ELECTRICAL SAFETY

Vehicles shall not contain exposed conductors, terminals, contact blocks or devices of any type that create the potential for personnel to be exposed to 60 volts or greater (the distinction between low-voltage and high voltage, as specified in SAE J1127, J1128, et al.). Access to any high voltage components shall require the removal of at least one bolt, screw, or latch. Devices considered to be high voltage components shall be clearly marked as HIGH VOLTAGE. These markings should be installed at any point the voltage can be accessed by the end user. Additionally, cable and wire marking shall consist of orange wire and/or orange sleeving as identified in SAE-J1127.

7.2 ELECTRICAL ISOLATION³

For propulsion power systems with voltages greater than or equal to 48VDC, the system shall be isolated from the vehicle chassis such that leakage current does not exceed 0.5 MIU.

Charging circuits for RESS battery systems with voltages greater than or equal to 48VDC shall be isolated from the vehicle chassis such that ground current from the grounded chassis does not exceed 5 mA at any time the vehicle is connected to an off-board power supply. Supplier should provide details on grounding and isolation methods.

7.3 BATTERY DISCONNECT⁴

Vehicles should be equipped with an automatic disconnect for the RESS batteries which operates to isolate the propulsion circuits any time the chassis becomes energized from contact with the propulsion battery or its associated circuits. This disconnect shall be capable of interrupting maximum rated controller/inverter current. The Supplier shall describe the automatic disconnect provided for the main propulsion batteries.

A manual service disconnect should also be present. This disconnect should be operable with the following capabilities:

- Manual action to break the connection
- The disconnection is physically verifiable
- The disconnection does not create exposed conductors capable of becoming energized while exposed.

³ This section does not apply to 42VDC auxiliary systems that use the chassis as the common return.

⁴ Manufacturer's may choose to install over-ride features to allow vehicles to move under their own power in situations where occupant safety is the primary concern (e.g., following a collision where moving the vehicle off the roadway is determined necessary to prevent injury/further injury or additional damage).

2001 HEV AMERICA FINAL TECHNICAL SPECIFICATIONS

7.3 BATTERY DISCONNECT (continued)

The key-switch may be used to satisfy the operability portion of the manual service disconnect requirement, if it interrupts all control power going to the controller and the main battery contactor(s). This disconnect is not required to operate under load.

7.4 SAFETY INTERLOCK SYSTEM

The vehicle shall be prevented from being driven with the key turned on and the drive selector in the drive or reverse position while the vehicle's charge cord is attached. Additionally, the following interlocks shall be present:

- The controller shall not initially energize to move the vehicle with the gear selector in any position other than "PARK" or "NEUTRAL;"
- The start key shall be removable only when the "ignition switch" is in the "OFF" position, with the drive selector in "PARK;"
- With a pre-existing accelerator input, the controller shall not energize or excite such that the vehicle can move under its own power from this condition.

7.5 OPERATION OF HAZARD LIGHTS

Hazard lights should be capable of at least one hour of continuous operation in the event of shutdown or isolation of the main battery pack or failure of the DC/DC converter system.

7.6 STATE OF CHARGE INDICATOR

The vehicle should include a state of charge indicator for the RESS batteries. Indications should be accurate to $\pm 5\%$ of full scale.

7.7 CONNECTORS

Low voltage connectors should meet the requirements of applicable SAE Standards, including J163, J561, J858, et al. High voltage connectors should utilize locking devices, should be keyed to prevent mis-connection, and should be moisture proof.

8.0 CHARGER SYSTEM FOR VEHICLES CAPABLE OF OFF-VEHICLE CHARGING (OVC)

8.1 CHARGER OPERATION

If the vehicle is capable of off-board recharging of the RESS, the charger shall be capable of recharging the RESS to a state of full charge from any possible state of discharge in less than 12 hours, at temperatures noted in Section 5.5, as applicable. The preferred recharge time should be less than eight (8) hours.

The charger should maintain each battery module at a consistent state of charge over the life cycle of the battery. The charger should not charge the batteries in a manner that would cause venting of gas or liquid. The charger shall be fully automatic, determining when “end of charge” conditions are met and transitioning into a mode that maintains the main propulsion battery at a full state of charge while not overcharging it, if continuously left on charge. The charger should also minimize the energy required to maintain the main propulsion battery in a fully charged state, particularly during extended periods on charge.

8.2 CHARGING INPUT POWER

If the vehicle is capable of off-board recharging of the RESS, the chargers shall use 120V or 208/240V single-phase 60-Hertz alternating current service, with an input voltage tolerance of $\pm 10\%$ of rated voltage. Input current for chargers operating at 208V and 240V shall be compatible with 40-ampere circuit breakers.

Personnel protection systems shall be in accordance with the requirements of UL Standard 2202 and shall be determined based upon RESS system voltages. All personnel protection systems shall meet the requirements specified in the applicable sections of UL2231-1 and 2231-2.

Any conductive or inductive type charging systems should be in accordance with the requirements of SAE J1772 or J1773.

8.3 POWER QUALITY

If the vehicle is capable of off-board recharging of the RESS using a 208/240V charger, chargers shall have a true power factor of .95 or greater and a harmonic distortion rated at $\leq 20\%$ (current at rated load).

8.4 VEHICLE CHARGER CONNECTIONS

Suppliers should describe the type, size and location of the point of the vehicle charging port. The charge connector should comply with the requirements of SAE J1772 or SAE J1773, as appropriate. Regardless of the charger type used, the charger shall conform to the requirements of UL Proposed Standard 2202.

9.0 ADDITIONAL VEHICLE SYSTEMS

Suppliers should describe the following options, if available. The installation of options shall not relieve Suppliers of meeting other “shall” requirements. Suppliers should specify the impact on range and payload for each option.

9.1 AIR CONDITIONING SYSTEM

Suppliers should describe the design of the air conditioning system and verify that it uses no chloroflourocarbons (CFCs).

9.2 OCCUPANT COMPARTMENT PRE-HEATING AND COOLING SYSTEM

Suppliers should briefly describe the design of a pre-heating and pre-cooling system that allows passenger compartment temperatures to be maintained while the vehicle is on charge.

**2001 HEV AMERICA FINAL
TECHNICAL SPECIFICATIONS**

10.0 DOCUMENTATION

10.1 SERVICE MANUALS

Vehicles shall be accompanied by non-proprietary manuals for parts, service, operation and maintenance, interconnection wiring diagrams and schematics. Manuals should include details on the design and operation of vehicle systems, as well as a list of additional or special maintenance tools required.

10.2 TRAINING PROGRAM

Suppliers should offer a training program for the purchaser's maintenance personnel covering vehicle safety and proper operation and maintenance of vehicles.

**2001 HEV AMERICA FINAL
TECHNICAL SPECIFICATIONS**

APPENDIX A

PERFORMANCE (in RESS only mode)

Time required to accelerate from 0-50 on a level grade(s) _____
Time required to accelerate from 0-55 on a 3% grade(s) _____
Time required to accelerate from 0-45 on a 6% grade(s) _____
Maximum speed attainable on a level grade (mph) _____
Maximum grade attainable from a standing start at GVWR (%) _____
Range at a constant speed of 45 mph (miles) _____
Range over the SAE J1634 combined UDS-HWFET cycle (miles) _____

BATTERY RESS CHARACTERISTICS (referenced to 25 °C)

Manufacturer _____
Model _____
Type _____
Description _____
Number of Batteries in the Pack _____
Arrangement (series or parallel) _____
Battery module voltage (VDC) _____
Battery pack voltage (VDC) _____
Battery module weight (kg) _____
Battery pack weight (kg) _____
Maximum normal gassing rate (scfm or cc/ml/m) _____
Maximum abnormal gassing rate (scfm or cc/ml/m) _____
Battery capacity to 100% Manufacturer's DOD, 1 hour rating (Ah) _____
Battery capacity to 100% Manufacturer's DOD, 2 hour rating (Ah) _____
Battery capacity to 100% Manufacturer's DOD, 3 hour rating (Ah) _____
Battery energy to 100% Manufacturer's DOD, 1 hour rating (Wh) _____
Battery energy to 100% Manufacturer's DOD, 2 hour rating (Wh) _____
Battery energy to 100% Manufacturer's DOD, 3 hour rating (Wh) _____
Probable life of an average battery to a Manufacturer's DOD of:
 50% DOD (cycles) _____
 80% DOD (cycles) _____
Time required to recharge the batteries from a DOD of:
 50% DOD (cycles) _____
 80% DOD (cycles) _____

**2001 HEV AMERICA FINAL
TECHNICAL SPECIFICATIONS**

APPENDIX A (cont)

CHARGER CHARACTERISTICS

Manufacturer _____
Model _____
UL file number _____
Description _____
Location _____
Charger efficiency (%) _____
Charger input voltages (VAC) _____
Charger input power factor (%) _____
Charger input total harmonic distortion (%) _____
Maximum charger current output (A) _____

MOTOR CHARACTERISTICS

Manufacturer _____
Model _____
Description _____
Type (AC, DC, Brushless, etc.) _____
Rated Efficiency _____ % @ _____ kW
Operating Range (RPM) _____
Maximum Intermittent Power _____ kW for _____ minutes
Maximum Continuous Power _____
Cooling Medium and Method _____

CONTROLLER CHARACTERISTICS

Manufacturer _____
Model _____
Description _____
Type and Phase _____
Input Voltage Range _____
Maximum Output (A) _____
Type of Power Electronics (IGBT, mosfet, etc.) _____
Rated Efficiency _____ % @ _____ A

**2001 HEV AMERICA FINAL
TECHNICAL SPECIFICATIONS**

APPENDIX A (cont)

HEAT ENGINE CHARACTERISTICS

Model _____
Configuration _____
Displacement (liters) _____
Number of Cylinders _____
Power (hp@rpm) _____
Torque (lb-ft@rpm) _____
Operating Range (rpm) _____
Recommended Fuel (all types) _____
Fuel Tank Capacity (liters) (specify for each fuel type) _____

TRANSMISSION CHARACTERISTICS

Manufacturer _____
Type _____
Model _____
Description _____
Gear Ratio(s) _____

CHASSIS CHARACTERISTICS - Pre-Conversion

Make, Year and Model _____
Gross vehicle weight rating (kg) _____
Gross axle weight rating (kg) _____ front _____ rear
Curb weight (kg) _____
Weight distribution _____ % front _____ % rear
Payload capacity (kg) _____
Ground clearance from lowest point on chassis at GVWR (cm) _____
Drive Wheels (F/R) _____

CHASSIS CHARACTERISTICS - Post-Conversion

Make, Year and Model _____
Gross vehicle weight rating (kg) _____
Gross axle weight rating (kg) _____ front _____ rear
Curb weight (kg) _____
Weight distribution _____ % front _____ % rear
Payload capacity (kg) _____
Ground clearance from lowest point on chassis at GVWR (cm) _____
Drive Wheels (F/R) _____

**2001 HEV AMERICA FINAL
TECHNICAL SPECIFICATIONS**

APPENDIX A (cont.)

BRAKES

Type front _____
Type rear _____
Power source, if used _____
Average power, if used (W) _____
Maximum regenerative braking (kW) _____

TIRES

Manufacturer _____
Model _____
Description _____
Size and profile _____
Pressure (psi) _____ front _____ rear
Weight capacity (lbs) _____

SUSPENSION

Type front _____
Type rear _____
Modifications made during conversion, if any _____

STEERING

Type _____
Description _____
Manufacturer _____
Power source, if used _____
Average power, if used (W) _____

AIR CONDITIONING

Description _____
Compressor type _____
Maximum cooling output (BTU/hr) _____
Motor type _____
Maximum power required (kW) _____

HEATING

Description _____
Type _____
Maximum heating output (BTU/hr) _____
Maximum power required (kW) _____